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TELEMETRY ENCODER FOR INTERNATIONAL SATELLITE S-52/UK-2

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ABSTRACT

The S-52/UK-2 satellite is the latest in a series of satellites to utilize Pulse Frequency Modulation. This paper documents design aspects of the S-52 encoder on a functional block basis and discusses in detail some new circuitry which is a significant improvement over instrumentation of earlier PFM encoders. Desired end results were an increase in reliability, a reduction in power dissipation, and simplification of instrumentation circuitry wherever possible, while maintaining or improving system capabilities and performance. In achieving desired design aims the solution of attendant generated problems yielded much useful information, particularly in the area of high reliability semiconductors. AUTHOR

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SUMMARY

The S-52/UK-2 is the second satellite in the cooperative space program between the United States and the United Kingdom. As in the UK-1 satellite, the British are responsible for the experiments, which include design of sensor and associated instrumentation, and for final data reduction and analysis. The United States is responsible for the spacecraft and all associated instrumentation (excluding the experiments), launch vehicle, launch site, launch operations, tracking, data acquisition, and some preliminary data reduction.

Aboard the S-52/UK-2 satellite are three experiments. An Ozone experiment measures the vertical distribution of ozone in the earth's atmosphere. The Galactic Noise experiment measures the 0.75 Mc to 3.0 Mc radio frequency spectrum above the ionosphere. Finally, the Micrometeoroid experiment measures particle flux in terms of quantity and size.

The S-52/UK-2 encoder utilizes Pulse Frequency Modulation, a time-division-multiplex telemetry system which has been successfully employed as the encoding technique in a number of

small scientific United States earth satellites where reduction of power and weight are primary considerations. The PFM signal consists of a series of sequential pulses; the frequency of each pulse conveys the information and is proportional to the amplitude of the input signal.

The S-52/UK-2 encoder is actually two encoders. A so-called high speed encoder modulates the carrier directly and is sent in real time. The second encoder, the low speed encoder, through the use of a tape recorder, enables the acquisition of data at critical times when the spacecraft may be out of the range of a tracking station. Each encoder has two modes of operation. Eight primary experiment outputs and eight experiment housekeeping parameters are combined with eight spacecraft housekeeping parameters and synchronization and identification signals in pre-determined formats or sequences dictated primarily by required experiment sampling rates.

Functionally, a clock circuit provides a tuning fork stabilized reference frequency which drives complementary bistable flip-flops in both encoders. These in turn drive logic circuitry which generates necessary gating functions, including turning on oscillators characterized by low power (2 mw. in standby), high input impedance (>5 meg), short stabilization time (1/2 cycle), and high accuracy, linearity and stability (≤1/2% error). Oscillators are driven directly from experiment

or housekeeping outputs or through transistor commutating switches. DC output voltages from 0 to plus 5 volts are transposed linearly into frequencies from 15 kc to 5 kc, respectively. For the Galactic Noise and Ozone experiments, sample and hold circuits can sample output signals varying at rates up to 500 volts/sec. and hold them at the oscillator input for more than 1 second with less than 1% droop. The basic analog oscillator can be easily adapted for use as sync or digital (8 level) frame identification in the formats. Outputs of the eight oscillators in the high speed encoder are commoned (only one oscillator being on at a time) as are the outputs of the three low speed oscillators, and both signals are sent to the programmer for immediate or delayed (tape recorder) transmission.

Reliability was a major consideration throughout the encoder design. One facet was directed toward component evaluation and selection, particularly high reliability transistors. Redundancy was used sparingly in circuit design. Each experiment has two oscillators to minimize the probability of total loss of data from any one experiment. In the event of failure, oscillators were designed to increase the probability of failing OFF instead of ON, thus reducing the probability of interference or garbling of two outputs. All welded construction was employed throughout fabrication, from the smallest module to the completed system packages.

While welded construction was specified to the fabricator (Westinghouse Air Arm) for reliability reasons, several problems resulted. These included difficulty in trouble shooting and repair and magnetization of the nickel ribbon wire used for connections. (This caused frequency instabilities or deviations in oscillator outputs with orientation in the earth's field.)

The physical and electrical characteristics of the S-52/UK-2 encoder are as follows:

Volume: 104 cu. inches (4 trapezoidally shaped packages, each one inch thick)

Weight: Approx. 4-1/4 pounds

Power: Sample and Hold Circuit card - 24 mw. (average)

Rest of the encoder - 87 mw. (average)

The sample and hold power is listed separately since its inclusion was a last minute requirement and power allotments were eased.